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Word-of-Mouth Communication and Price as a Signal of Quality*

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This paper demonstrates that word-of-mouth communication between consumers provides a mechanism to support signalling. Particularly, a separating equilibrium can be supported where a low introductory price signals high quality. The equilibrium price path is qualitatively similar to that supported by repeat buying. Separation is less likely than in repeat buying because word-of-mouth communication between consumers is likely to be less effective in transmitting information than repeat buying. The equivalence of word-of-mouth communication and repeat buying breaks down entirely when communication is costly because consumers then have a strict incentive not to communicate if separation occurs. This undermines the mechanism that supports the separation.

I Introduction

There are two principal mechanisms through which price can potentially signal the quality of a newly introduced product: a quality-based cost differential and reputation effects. The cost differential mechanism was first proposed by Schmalensee (1978). If a high-quality product has a higher marginal production cost than a low-quality product then initial sales at a given price will be more valuable to the seller of a low-quality product than the seller of a high-quality product. This means that the high-quality seller may be able to signal high quality by setting a high introductory price: a high price tells consumers that the seller can afford to forego sales because its marginal costs are high. If the correlation between high costs and high quality is understood then consumers can infer from the high price that the product is high quality. Milgrom and Roberts (1986) and Bagwell and Riordan (1991) formally derive signalling results of this type.

The importance of reputation effects was first recognized by Nelson (1974), who focused on the role of repeat buying. Nelson argued that a high-quality product is likely to attract more repeat sales than a low-quality one. This means that the seller of a high-quality product may be more willing to forego initial profits by offering the product at a low introductory price than will the seller of a low-quality product. This asymmetry between high- and low-quality sellers creates the potential for price to signal quality. Milgrom and Roberts (1986) and Miller (1988) show that a low introductory price can signal high quality in this way.

The purpose of this paper is to examine a somewhat different reputation mechanism: word-of-mouth communication between consumers. In many cases word-of-mouth communication will be much more important than repeat buying in establishing a product's reputation. This is likely to be especially true in the case of goods that are purchased relatively infrequently, such as durable goods. The time lapse between purchase and

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repeat purchase for these goods is such that the present value to the firm of a reputation built on repeat buying alone is likely to be small and relatively ineffective in supporting signalling. Moreover, the set of consumers who are in the market for these goods at any particular time will generally be different across time. This means that much of the demand for a new product, even in periods subsequent to its introduction, will stem from consumers who have no previous experience with it. These consumers will rely on communication with other consumers to obtain information on product quality.[1]

Word-of-mouth communication is in some respects functionally equivalent to repeat buying in terms of providing a mechanism for signalling. In both cases there is a transfer of information about quality from a consumer in one period to a consumer in the next period. In the case of repeat buying the consumer has the same identity in both periods but this is largely irrelevant from the firm's perspective. However, there is a key difference between word-of-mouth communication and repeat buying that can have important implications for introductory price equilibria. This difference relates to the cost of information transmission. A repeat buyer automatically acquires information about product quality as a result of her initial purchase. In contrast, word-of-mouth communication between consumers requires a deliberate action and that action may be costly. In a separating equilibrium in which the firm has signalled its quality there can be no benefit to the inexperienced consumer from seeking information, and so if communication is costly they will seek no information. This can undermine the mechanism that supports the signalling.

The rest of this paper examines in more detail signalling equilibria in a market with word-of-mouth communication, and highlights the difference between word-of-mouth communication and repeat buying. Section II presents a simple model. Section III characterizes the signalling equilibria when word-of-mouth communication is costless. Section IV then examines the implications of costly communication. Section V concludes. An appendix contains those proofs not included in the main text.

[1] 'Word-of-mouth communication' will be used to describe any exchange of information between consumers, ranging from casual discussion with friends or neighbours to reference to consumer survey publications.

II The Model

Time is divided into three periods. In period zero a single firm develops a new product x. The new product is high quality with probability $\rho_0 \in [0,1)$ and low quality with probability $1 - \rho_0$. These probabilities are common knowledge. A high-quality product provides a discounted stream of utility $v - p$ to a consumer with valuation v who pays price p for it. A low-quality product yields no service and so provides utility $-p$. Quality is not observable prior to purchase and a warranty cannot be offered.[2] The product is produced at a constant marginal cost c that is independent of quality. I make this assumption to eliminate the possibility of signalling via the cost differential mechanism outlined in the introduction; the focus of the paper is the reputational channel for signalling. Moreover, it is a reasonable assumption in many instances. The quality of a product is often largely determined by the quality of research that has gone into its development. For example, the quality of a software package is primarily a function of the development process, and this is quite independent of the marginal cost of production.

There are two over-lapping generations of consumers who have a potential demand for the product. The first generation is young in period zero and old in period one, while the second generation is young in period one and old in period two. Consumers have a demand for the product only when they are old and each consumer has use for at most one unit. This differentiation between consumers on the basis of 'age' is designed to capture the fact that different consumers will be active in the market for a product at different times. Each generation comprises a continuum of consumers distributed uniformly over the interval $[0,\bar{v}]$ with mass $\bar{v}$.

Information about the quality of the new product can pass between generations via word-of-mouth communication. The probability $r \in [0,1)$

[2] There are two reasons why full warranties can rarely be offered. First, there is a moral hazard associated with guaranteeing a product against failure when the probability of failure is a function of the consumer's treatment of the product. Second, it is often difficult to verify product failure and measure its associated utility cost. In particular, product 'failure' is sometimes a very subjective matter: a consumer's dissatisfaction with a product may simply be due to a mismatch between the product's characteristics and the consumer's idiosyncratic tastes.

with which a second-generation consumer receives a report from a first-generation consumer is increasing and concave in the volume of first period sales x_1. That is: $r'(x_1) > 0$ and $r''(x_1) < 0$. This implies that the likelihood with which a consumer receives information on a product increases with the number of people who have bought the product in the past.

The introduction of the new product is modelled as an extensive form game. Play proceeds as follows. The product is developed in period zero. At the beginning of period one the firm introduces the new product at a price p_1. Consumers revise their beliefs about quality on the basis of this announced price. This posterior belief is denoted $\rho_1 \in [0,1]$. First-generation consumers then make their purchase decisions to maximize expected utility. A consumer who makes a purchase immediately observes whether the product is high or low quality. At the beginning of the second period the firm announces a second-period price p_2. Second-generation consumers revise their beliefs about quality on the basis of this price. This posterior belief is denoted $\rho_2 \in [0,1]$. Some of these second-generation consumers may then receive, via word-of-mouth communication with first-generation consumers, a report on the quality of the product and further revise their beliefs accordingly. Second-period consumers then make their purchase decisions and the game ends.

Consider the demand functions associated with this model. A consumer will make a purchase if and only if the expected utility from a purchase is non-negative. If the announced price in the first period is p_1 then the expected utility to a first-generation consumer from a purchase is $\rho_1 v_1 - p_1$. The marginal first-generation buyer is therefore defined by $v_1^* = p_1/\rho_1$ and all consumers for whom $v \geq v_1^*$ make a purchase. First-period demand is therefore given by

$$x_1 = \bar{v} - p_1/\rho_1 \text{ if } \rho_1 > 0 \text{ and } p_1 \leq \rho_1 \bar{v}$$
$$= 0 \text{ otherwise} \qquad (1)$$

It will never be profitable for the firm to set $p_1 > \rho_1 \bar{v}$ so hereafter attention is restricted to $p_1 \leq \rho_1 \bar{v}$. Second-generation consumers will be randomly partitioned into two subsets according to whether or not they become informed through word-of-mouth communication. Recall that the probability of becoming informed is $r(x_1)$, so the set of informed second-generation consumers will have mass $r(x_1)\bar{v}$ while the set of uninformed second-generation consumers will have mass $(1 - r(x_1))\bar{v}$. If the product is low quality then none of the informed consumers will make a purchase and demand will stem only from those uninformed consumers for whom $v > p_2/\rho_2$. Hence, second-period demand for a low-quality product will be

$$x_2^L = (1 - r(x_1))(\bar{v} - p_2/\rho_2)$$
$$\text{if } \rho_2 > 0 \text{ and } p_2 \leq \rho_2 \bar{v}$$
$$= 0 \text{ otherwise} \qquad (2)$$

If the product is high quality then all of those informed consumers for whom $v \geq p_2$, together with those uninformed consumers for whom $v \geq p_2/\rho_2$, will make a purchase and so demand is given by

$$x_2^H = r(x_1)(\bar{v} - p_2) + (1 - r(x_1))(\bar{v} - p_2/\rho_2)$$
$$\text{for } \rho_2 > 0 \text{ and } p_2 \leq \rho_2 \bar{v}$$
$$= r(x_1)(\bar{v} - p_2) \text{ otherwise} \qquad (3)$$

To simplify the analysis, consideration is confined to the case where word-of-mouth communication is not so effective as to ever make it profitable for the firm to sell exclusively to informed consumers. Hence, attention is restricted to the case where $p_2 \leq \rho_2 \bar{v}$.

III Signalling with Costless Communication

Attention is confined to perfect Bayesian equilibria in pure strategies.[3] A perfect Bayesian equilibrium is a vector of strategies and a system of beliefs such that (i) each player's strategy maximizes her expected payoff (starting from any node in the game) given her beliefs and the equilibrium strategies of the other players; and (ii) beliefs are computed from strategies using Bayes's rule when applicable. More formally:

Definition. Let $u^i(p_1, p_2, \rho_1, \rho_2)$ be the discounted profit stream from a product of quality i, given prices $\{p_1, p_2\}$ and beliefs $\{\rho_1, \rho_2\}$. That is,

$$u^i(p_1, p_2, \rho_1, \rho_2) = (p_1 - c)x_1(p_1, \rho_1)$$
$$+ \delta(p_2 - c)x_2^i(p_1, p_2, \rho_1, \rho_2)$$

where $\delta \in (0,1)$ is the firm's discount factor and the demand functions are as defined in (1) through (3). A *perfect Bayesian equilibrium* is a set of prices $\{p_1^H, p_2^H, p_1^L, p_2^L\}$ and posterior beliefs $\{\rho_1(p_1), \rho_2(p_1, p_2)\}$ satisfying individual rationality conditions:

[3] In signalling games such as this one, perfect Bayesian equilibria coincide with the Kreps and Wilson (1982) notion of sequential equilibria.

$$u^H [p_1^H, p_2^H \rho_1 (p_1^H), \rho^2 (p_1^H, p_2^H)]$$

$$\geq u^H [p_1, p_2, \rho_1 (p_1), \rho_2 (p_1, p_2)] \; \forall p_1, p_2 \quad (4)$$

$$u^L [p_1^L, p_2^L \rho_1 (p_1^L), \rho^2 (p_1^L, p_2^L)]$$

$$\geq u^L [p_1, p_2, \rho_1 (p_1), \rho_2 (p_1, p_2)] \; \forall p_1, p_2 \quad (5)$$

and belief consistency conditions:

$$\rho_1 (p_1^H) = \rho_1 (p_1^L) = \rho_0$$

$$\text{and } \rho_2 (p_1^H, p_2^H) = \rho_2 (p_1^L, p_2^L) = \rho_0$$

$$\text{if } p_1^H = p_1^L \text{ and } p_2^H = p_2^L \quad (6)$$

$$\rho_1 (p_1^H) = \rho_2 (p_1^H, p_2^H) = 1$$

$$\text{and } \rho_1 (p_1^L) = \rho_2 (p_1^L, p_2^L) = 0$$

$$\text{if } p_1^H \neq p_1^L \quad (7)$$

$$\rho_1 (p_1^H) = \rho_1 (p_1^L) = \rho_0, \rho_2 (p_1^H, p_2^H) = 1$$

$$\text{and } \rho_2 (p_1^L, p_2^L) = 0$$

$$\text{if } p_1^H = p_1^L \text{ but } p_2^H \neq p_2^L \quad (8)$$

Expressions (4) and (5) state that the firm's prices are optimal given its type (the quality of its product) and given the equilibrium demand it faces. The optimality of consumer decisions, given their beliefs and given the firm's equilibrium prices, is implicit in the demand functions. Expressions (6) through (8) state that equilibrium beliefs are derived from strategies and are consistent with Bayes's rule.

Two types of equilibria can be identified here. Condition (6) describes pooling equilibria in which both types choose the same prices; prices therefore convey no information to consumers. Conditions (7) and (8) describe separating or signalling equilibria in which different types choose different prices and in so doing signal their type to consumers. I intend to focus only on the separating equilibria since I am primarily interested in the potential for signalling in this environment.[4]

Separation can potentially occur in the first or second period. Condition (7) describes separation in the first period while condition (8) describes separation only in the second period. If separation occurs at all in this game then it must occur in the first period, for the following reason. If there is a pooling outcome in the first period then any second-period price that is profitable for the high-quality type will also be profitable for the low-quality type because there will always be some uninformed second-generation consumers since information transmission is incomplete. The high-quality type therefore cannot distinguish itself through the second-period price alone. This also means that a low-quality type will never pursue a 'fly-by-night' strategy wherein it chooses a pooling price in the first period and then exits in the second period.

Separation in the first period implies that $p_1^H \neq p_1^L$, so $\rho_1 (p_1^H) = 1$ and $\rho_1(p_1^L) = 0$. When $\rho_1 = 0$ the payoff to the firm is zero and so the product will not be introduced. A strategy p_1^L shall accordingly be interpreted as a non-introduction strategy. Beliefs must be confirmed in equilibrium and this requires that the type-contingent prices be incentive compatible. That is, in a separating equilibrium,

$$u^H (p_1^H, p_2^H, 1, 1) > 0 \quad (9)$$

$$0 > u^L (p_1^H, p_2^H, 1, 1) \quad (10)$$

The first condition states that the high-quality type should prefer its own equilibrium strategy to mimicking the equilibrium strategy of the low-quality type. The second condition is an analogous requirement for the low-quality type.

If there exist any equilibria satisfying conditions (9) and (10) then there will generally exist a continuum of such equilibria. This multiplicity stems from the absence of any restrictions on out-of-equilibrium beliefs. In order to refine the set of equilibria it is necessary to place explicit restrictions on those beliefs. The refinement criterion used here is the now standard *intuitive criterion* of Cho and Kreps (1987). The intuitive criterion imposes the following restriction on beliefs in this game. If the firm deviates from some candidate equilibrium by choosing a strategy that yields a higher payoff than the candidate equilibrium only if by doing so it can convince consumers that it is a high-quality type, and *for any beliefs* yields for the low-quality type a payoff lower than the candidate equilibrium payoff, then consumers will believe with probability one that the deviating firm is a high-quality type. Imposing this refinement yields a unique separating equilibrium in this game:

[4] I examine pooling equilibria in an earlier and longer version of this paper. See Kennedy (1991).

Proposition 1 If an intuitive separating equilibrium exists then it is unique. In this equilibrium,

$$p_1^H \equiv \hat{p}_1 = \max \{p_1: (p_1 - c)(\bar{v} - p_1) + (\delta/4)(1 - r(\bar{v} - p_1))(\bar{v} - c)^2 < 0\}$$

and

$$p_2^H \equiv \hat{p}_2 = \underset{p_2}{\text{argmax}}\ (p_2 - c)(\bar{v} - p_2) = (\bar{v} + c)/2$$

Proof See the appendix.

To see why this must be so consider first the second-period price. The choice of a separating price in the first period informs second-generation consumers that the product is high quality, and in equilibrium they receive no reports to the contrary. The firm is then able to charge the profit-maximizing full information price in the second period. This price is $\hat{p}_2$. Next consider the first-period price $\hat{p}_1$. This is the maximum price satisfying incentive compatibility condition (10). No candidate equilibrium price less than or equal to $\hat{p}_1$ can satisfy the intuitive criterion because $\hat{p}_1$ is unprofitable for the low-quality type even if $\rho_1 = 1$, and all $p_1 < \hat{p}_1$ yield a strictly lower payoff than $\hat{p}_1$ for the high-quality firm when $\rho_1(\hat{p}_1) = 1$.

Note that no word-of-mouth communication actually takes place in the separating equilibrium. There is no need for it. Second-generation consumers become informed by the separating price and so they have no incentive to engage in communication. However, the threat of communication should separation not take place is sufficient to ensure that the low-quality type does not mimic the separating price.

Proposition 2 In the intuitive separating equilibrium, the firm signals high quality with a low introductory price (relative to the full information price). Price then rises over time.

Proof See the appendix.

This result has the following intuition. A low introductory price boosts first-period sales and thereby increases the likelihood with which second-period consumers become informed through word-of-mouth communication. This is to the firm's advantage if the product is high quality and to its detriment if the product is low quality. This asymmetry allows a low introductory price to signal high quality. Once separation has occurred, the firm can charge the full information price in the second period. Thus, price rises over time.

The first-period equilibrium is illustrated in Figure 1. The 'mimicking' payoff to the low-quality type $u^L(p_1, \hat{p}_2, 1, 1)$ and the equilibrium payoff to the high-quality type $u^H(p_1, \hat{p}_2, 1, 1)$ deviate increasingly as the introductory price falls. This deviation reflects the decline in second-period profit to the low-quality type as first-period sales rise and more second-generation consumers become informed of its true quality. The full information first-period price is illustrated as p_1^*.

Existence of the separating equilibrium requires that the candidate equilibrium prices in proposition 1 be individually rational for the high-quality type. That is,

$$(\hat{p}_1 - c)(\bar{v} - \hat{p}_1) + \delta(\bar{v} - c)^2/4 > 0. \qquad (11)$$

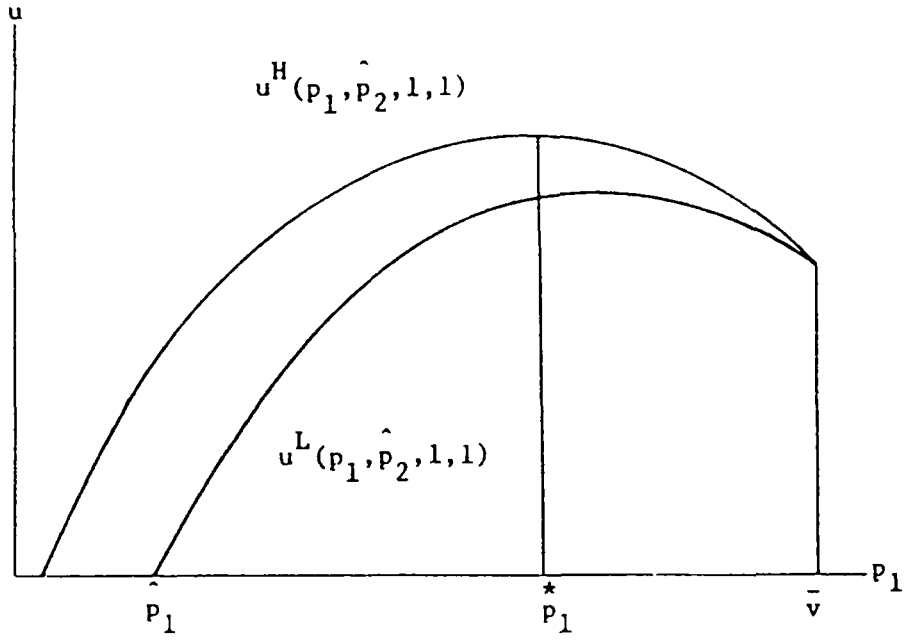
This condition is equivalent to condition (9), so if the candidate equilibrium exists then both incentive compatibility constraints are satisfied. Whether or not (11) is likely to be satisfied depends on how low $\hat{p}_1$ must be in order to be a separating price. This in turn depends on the efficacy of the word-of-mouth communication mechanism. If there is a high degree of information flow between generations then the introductory discount required to generate separation will be relatively small and separation is more likely to be profitable for the high-quality type. The separating equilibrium is therefore more likely to exist. Conversely, if word-of-communication is relatively ineffective at transmitting information then separation is less likely.

IV The Implications of Costly Communication

The foregoing analysis assumed that reports about product quality pass freely between generations. This section considers the implications of costly communication. A second-generation consumer must now incur a utility cost s (independent of her valuation of the product) in order to communicate with first-generation consumers. Communication is a binary action; it is either undertaken or it is not. It may be helpful to interpret the cost of communication as the cost of purchasing a consumer report magazine. As in the previous section, the probability $r \in [0,1)$ with which communication is successful in locating a reliable report on the product's quality is an increasing function of the volume of first-period sales.

A second-generation consumer will choose to undertake communication if and only if (i) the expected utility from doing so is non-negative; and (ii) the expected utility from doing so is at least as great as from making an uninformed purchase. Communication is successful in locating a

FIGURE 1



report with probability $r(x_1)$ and this report will be favourable with probability ρ_2. If the report is unfavourable then no purchase will be made. If no report is obtained then a purchase will be made if and only if $\rho_2 v \geq p_2$. Hence, the expected utility from undertaking communication is

$$Eu^c = r(x_1) \max [0, \rho_2 (v - p_2)] + [1 - r(x_1)] \max [0, \rho_2 v - p_2] - s \quad (12)$$

while the expected utility from not undertaking communication is

$$Eu^0 = \max [0, \rho_2 v - p_2]. \quad (13)$$

Communication will generally not be optimal for all consumers when $s > 0$. This will tend to reduce second-period demand for the high-quality product relative to the costless communication case because fewer second-generation consumers become informed about the true quality of the product. This effect on demand is continuous in s and one might expect the equilibrium of the altered game to also be continuous in s. This is in fact not so:

Proposition 3 If $s > 0$ then no separating equilibrium exists.

Proof The proof is by contradiction. Suppose separation occurs in period one. Then $\rho_2 \in \{0, 1\}$ and by (12) and (13) $Eu^c < Eu^0 \; \forall v$ if $s > 0$. Therefore, no second-generation consumers will undertake communication and the asymmetry between types required to support separation is lost. Consequently, no separating equilibrium exists.■

This result arises because second-generation consumers have a strict incentive not to undertake communication once separation has occurred. Recall that when communication is costless no communication actually takes place but the threat of communication is sufficient to support separation. That 'threat' is no longer credible when communication is costly and so the separating equilibrium breaks down.[5] This fragility of the separating equilibrium is the key distinction between an environment with word-of-mouth communication and one with repeat buying. It suggests that word-of-mouth communication cannot be relied upon to support signalling in markets where repeat buying does not do so.

[5] Grossman and Stiglitz (1980) have argued that this type of paradox in general renders informationally efficient markets impossible.

Is there any scope for the market to circumvent the problem posed by communication costs in supporting a signalling role for price? The problem stems from the non-credibility of the threat of communication once separation has occurred. The credibility of this threat can be restored (and the separating equilibrium resurrected) if consumers can commit to communicate. This commitment can be achieved if the cost of communication is sunk before the product is introduced. A regular subscription to (rather than a one-off purchase of) a consumer report service could possibly provide such a commitment. However, even if commitment to communication is possible, a separating equilibrium is less likely to exist than when communication is free. The reason relates to the incentive consumers have to free-ride. If enough consumers commit to communicate then separation can occur and all consumers will receive the associated benefits regardless of whether or not they made a communication commitment themselves. In this respect, prior commitment is a public good. There may therefore be an associated role for government intervention in the provision of consumer information services in order to ensure efficiency. The case for this role is strengthened by the presence of a second externality. First-generation consumers also gain from the separation induced by communication commitments by second-generation consumers (in the form of a lower first-period price and information on quality) but this positive externality is not priced and so there will tend to be too little communication. One might argue that government intervention is unnecessary here because high-quality sellers themselves will have an incentive to correct the externality problem by subsidizing information provision services. There are in fact some instances of this in real markets.[6] However, there is a potential moral hazard problem here and consumers may sensibly mistrust information services that are funded by the firms about whose products information is being provided.[7]

[6] For example, the Better Business Bureau in Canada is an industry-sponsored service that registers consumer complaints about firms and products and then releases this information to other consumers on request.

[7] For example, it is well known that automobile magazines tend to be relatively uncritical in their assessments of new cars for fear of losing advertising patronage.

V Conclusion

This paper has demonstrated that word-of-mouth communication between consumers can provide a mechanism to support signalling. In particular, a separating equilibrium can be supported in which a low introductory price signals high quality. The equilibrium price path is qualitatively similar to that supported by repeat buying. However, the functional equivalence of word-of-mouth communication and repeat buying as mechanisms to support signalling breaks down when communication is costly because consumers have a strict incentive not to communicate if separation occurs. This undermines the mechanism that supports the separation.

APPENDIX

Proof of proposition 1 First consider the second-period price. If p_1^H is a separating equilibrium price then $\rho_2 = 1$. The firm then faces a second-period demand given by (3) with $\rho_2 = 1$ and chooses p_2 to maximize second-period profit given this demand. This price is $\hat{p}_2$.

Next consider the first-period price. Using expression (2) for low-quality demand with $\rho_2 = 1$, together with the expression for $\hat{p}_2$, incentive compatibility condition (10) can be written as

$$(p_1 - c)(\bar{v} - p_1) + (\delta/4)(1 - r(\bar{v} - p_1))(\bar{v} - c)^2 < 0 \qquad (A1)$$

Let $\mathcal{P}^S$ be the set of p_1 satisfying (A1) and note that any $p_1 \in \mathcal{P}^S$ must yield a strictly lower pay-off for the low-quality type than a non-introduction strategy, regardless of the beliefs it induces. Note also that the second term in (A1) must be strictly positive since $\bar{v} > c$, so $p_1 < c \ \forall p_1 \in \mathcal{P}^S$. It follows that $(p_1 - c)(\bar{v} - p_1)$ is strictly increasing in $p_1 \ \forall p_1 \in \mathcal{P}^S$ and so $u^H(p_1, \hat{p}_2, 1, 1)$ is also strictly increasing in $p_1 \ \forall p_1 \in \mathcal{P}^S$. It then follows that the only equilibrium first-period price that cannot be broken by the intuitive criterion is $\hat{p}_1$. ■

Proof of proposition 2 It follows from the proof of proposition 1 that $\hat{p}_1 < c$. The full information price for the high quality type is:

$$p_1^* = \operatorname*{argmax}_{p_1} (p_1 - c)(\bar{v} - p_1) = (\bar{v} + c)/2$$

Since $p_1^* > c$, it follows that $\hat{p}_1 < p_1^*$. Since $\hat{p}_1 < p_1^*$ and since $\hat{p}_2 = p_1^*$ (by proposition 1), it further follows that $\hat{p}_1 < p_2^*$. ■

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